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PLAGIOCLASE DETERMINATION BY THE MODIFIED UNIVERSAL STAGE

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ABSTRACT

The modified universal stage having two horizontal east-west axes of rotation is applied to the determinative procedures for plagioclase feldspars and their twin laws, as originally introduced by Fedorov and elaborated more recently by others. The modified universal stage both simplifies and speeds up the procedure by permitting added steps of manipulation. A description is given of the application of this stage to this problem. Appended are necessary diagrams to facilitate calculation by graphical methods. *No graphical construction is required for critically orienting the crystal.* Very little and very simple and elementary construction is required for the determination of the anorthite content of plagioclase. Only slightly more is needed to determine the twin law. The procedure is given as a routine.

INTRODUCTION

The universal stage for which Fedorov is doubtless best known to us, has yielded to foreign petrographers and mineralogists a degree of success in the study of feldspars which has been largely foregone in America, if we may judge from our literature. Since Wright's masterful treatise on petrographic methods, published in 1911 (1), in which he lucidly and adequately outlined the principles of the technique, there has been little active response in applying these resourceful methods to American petrographic problems, due doubtless to the time required for their execution. Recently the writer described a modified universal stage and a simplified and rapid procedure for orienting and determining crystals on it *by immersion methods* (2). It is the intention here to outline the application of this modified stage to the determination *in thin section* of plagioclase feldspars and their twin laws in the hope that the time saving afforded by the modified instrument will encourage its use by some of those who have felt in the past that the results did not justify the time required to obtain them. The time saving is accomplished by executing very simply on the instrument several steps of manipulation which involve graphical

procedure for the operator of the earlier stage: such, for example, as the ready determination of 2V by Berek's method (3), or the change from one critical orientation to another, or the very fundamental step of orienting the crystal itself. In brief, the method consists in relating the orientation of the elements of optic symmetry of plagioclase to the elements of crystallographic symmetry as revealed by the planes, poles and axes of twinning and cleavage. We shall use the extensive data and graphs of feldspar properties compiled by those eminent European and Russian crystallographers who have laid so sound a foundation in recent years for this type of work (4).¹

EQUIPMENT AND PREPARATION OF THE MOUNT

A thin section is mounted on the universal stage with liquid contacts between the upper hemisphere and the central glass plate. The lower hemisphere is then introduced, also with liquid contact, and the selected crystal is ready for orientation.² For feldspar study it is convenient to use hemispheres of index about 1.56 which lessens the corrections to be made for the difference between the indices of the crystal and hemispheres. On the Bausch & Lomb model universal stage are four posts placed on the inner stage in positions similar to those of the upper hemisphere thumb screws. These are intended to aid in the study of grains by immersion methods. Two of these posts may profitably be removed when studying thin sections to permit greater movement of the slide.

¹ The Bausch & Lomb Optical Co. manufactures a stage embodying the modification referred to here; and E. Leitz Co. recently announced an accessory to their stage for this purpose.

² The axes of the instrument have been variously named and the names abbreviated to initial letters by foreign writers on the subject with the result that there is no established nomenclature. In view of the prevailing lack of agreement I have deemed it desirable to use an English terminology for the English speaking reader. The initial letters have been used where convenient for abbreviations. The following table gives the correlations of the different nomenclatures. Reference may be had to fig. 1.

	Emmons	Reinhard	Berek	Duparc-Reinhard	Fedorov-Nikitin
Inner vertical axis (I. V.)	N	A ₁	N	N	
Inner east-west axis (I. E-W)	—	—	—	—	
North-south axis (N-S)	H	A ₂	H	H	
Outer vertical axis (O. V.)	A	A ₃	M	M	
Outer east-west axis (O. E-W)	K	A ₄	J	J	
Microscope axis (M)	M	A ₅	—	—	

The illumination should be carefully adjusted in studying plagioclase to obtain accurate results. The purpose is to be sure that the light path is parallel to the axis of the microscope. Direct the beam of the arc lamp or other source squarely onto the plane mirror. Adjust the mirror to give good light in the microscope. Then close down all diaphragms, especially the one below the polarizer³ and readjust the mirror. The light should be at the center on the cross hairs when viewed through the bertrand lens.

It is not essential to use an objective provided with an iris diaphragm. Such a diaphragm contributes to sharper extinctions

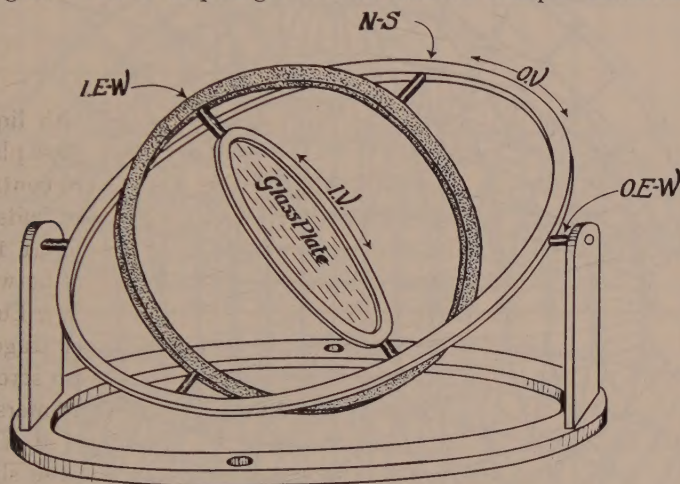


FIG. 1. Showing the five axes of the Bausch & Lomb Universal Stage.

however and is desirable for accurate work. Preliminary or routine procedures may be done with an abundance of light, but the final adjustments, made for accuracy, are done with the several diaphragms cut down.

The many lenses should be tested for strain as a preliminary check. This test is especially desirable for this type of work though it should be made on every petrographic microscope. The most satisfactory test is made with a Berek compensator, by which strain is easily detected as a change from a uniaxial to a biaxial figure. Such strain gives an erroneous orientation and consequently disturbs the results.

³ This may be obtained as a clamp-on accessory if not embodied in the microscope.

The method of orienting a biaxial crystal is given in two previous papers by the writer and need not be reviewed here (2) (5).

THE GENERAL PRINCIPLES OF PLAGIOCLASE DETERMINATION BY ROTATION

The earlier workers who have accomplished so much in this field have based their determinations on the fact that the orienta-

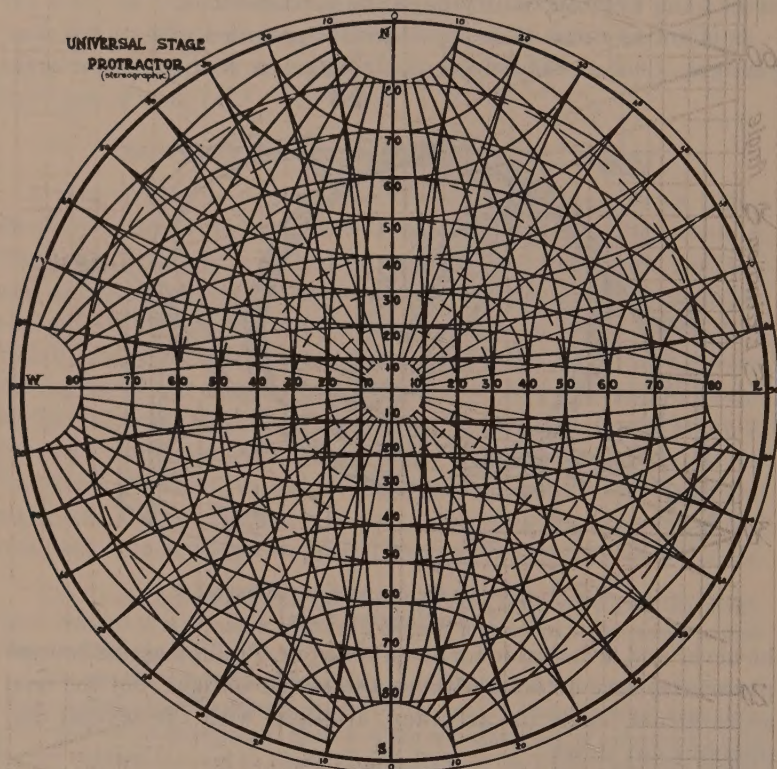


FIG. 2. The Fedorov net. The Wolff net is similar, differing in that it lacks some of the lines of the Fedorov net. The Fedorov net is especially convenient for making the various corrections. A gnomonic net similar to the Fedorov stereographic net is useful for corrections and some find it less confusing.

tion of the optic elements of plagioclase follow a progressive variation with respect to the crystallographic elements, a variation which is as characteristic of the series as are the index changes from albite to anorthite, or the change in $2V$, and sign. This orientation variation is graphically illustrated in modern descrip-

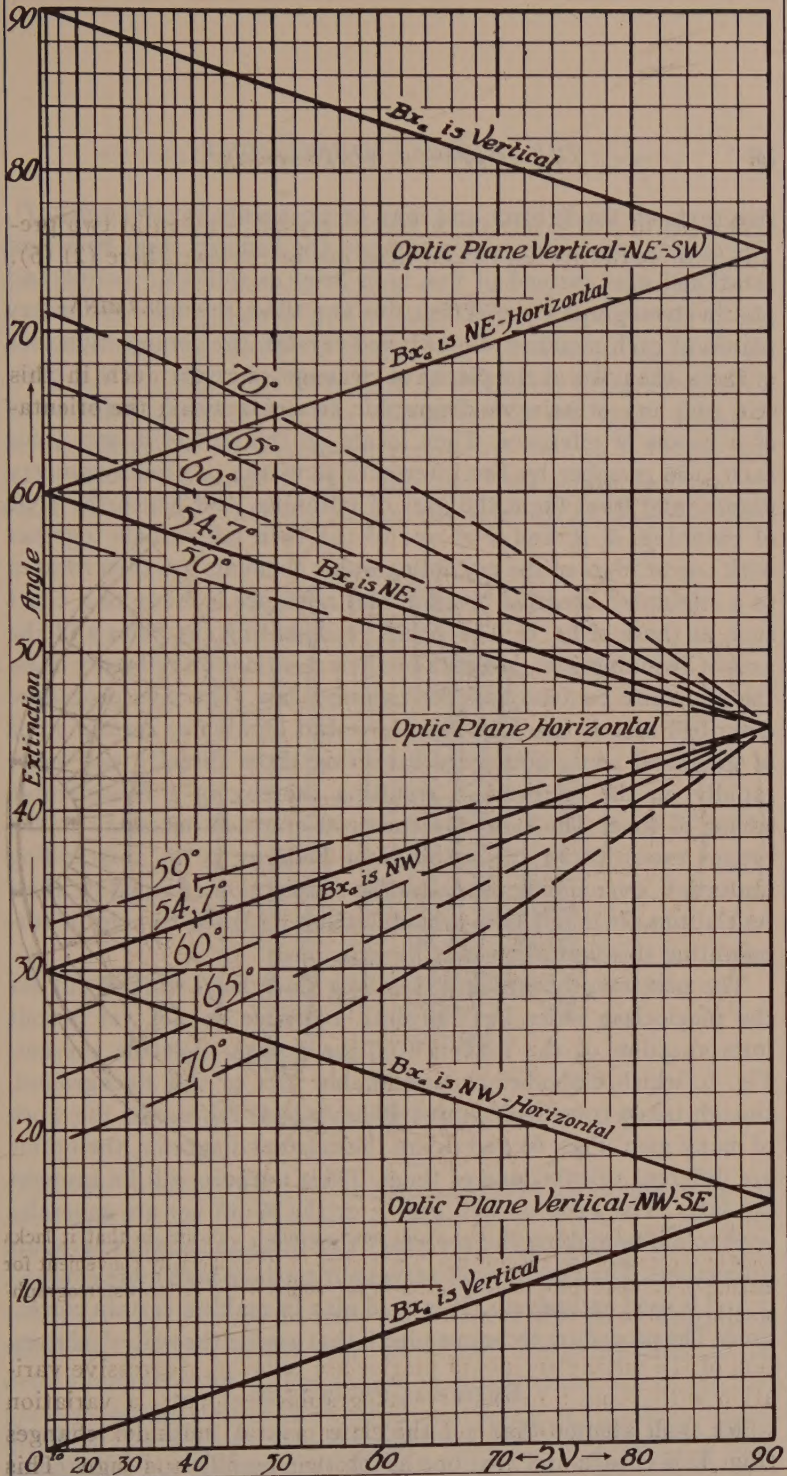


FIG. 3. This diagram is designed for use with feldspars only. It combines Berek's fundamental curves and Dodge's additional curves for the case in which the optic plane is horizontal and $2V$ may not be read directly. The abscissa scale is arranged to emphasize the inaccuracies of this method when applied to crystals of small $2V$.

tive texts on the subject and may be profitably reviewed (6) (7). The original procedure which employs the Fedorov stage with four rotational axes instead of five is in brief as follows,—orient and plot in stereographic projection, one at a time, the optic symmetry planes of each member of a twinned crystal, the composition face or faces, the poles of the planes of cleavage, of crystal faces if present, and any other crystallographic elements which might serve as a means of reference. Then locate on the plot α , β , and γ for each twin member by the intersections of the plotted symmetry planes, and from them the axes of twinning, and hence the type of twinning. α , β , and γ of one of the twin individuals together with one or more of the crystallographic elements are then rotated to a stipulated cardinal position and reference is made to a chart such as those of fig. 6. The points representing the poles and the axes of twinning, etc., indicate by their positions on reference lines, the anorthite content and the twinning law. The new procedure described here is based on the above but eliminates certain steps of graphical construction by executing them directly and more rapidly on the instrument, resulting thereby in a considerable saving of time. The excessive time consumption necessary to the proper execution of the methods of Fedorov is an outstanding limitation, overcoming for many the satisfaction afforded by their revelations. It is felt that a modification designed to help in surmounting this limitation may be welcomed.

The necessary background has long since been worked out for the plagioclase series but the data available do not yet permit interpretation of the influence of the potash molecule present. Fig. 6, which embodies a considerable part of this background, though taken from Nikitin and Reinhard (4) represents the work of many men. Figs. 6*b* and 6*e* are the original diagrams, the others are different orientations of them. Their purpose will be brought out later. The Fedorov net, Fig. 2, or the Wulff net are generally used to aid in making the necessary rotations on the stereographic projections. The Fedorov net serves our purpose here more generally and is used exclusively. It is used also in making certain corrections. The procedure recommended is that used in the writer's classes.

EMPIRICAL PROCEDURE

We shall assume that a plagioclase crystal, suitably twinned, (Fig. 4) is chosen and that one of the twin members is oriented so that α , β , or γ is parallel to the axis of the microscope.

(1) First, more should be learned about the details of the orientation. On the outer vertical axis rotate 45° in either direction but bear carefully in mind which way. To avoid confusion it is well to use one direction at all times when possible. This is the reference position for fig. 3. Rotate 54.7° *crystallographically* (i.e., corrected) on the outer E-W axis in whichever direction is more convenient, according to the inclination of the inner stage. If neither direction is convenient, rotate 90° (i.e., to the other 45° position) on the outer vertical axis and then rotate 54.7° on the outer E-W axis. Then rotate on the microscope stage counter-

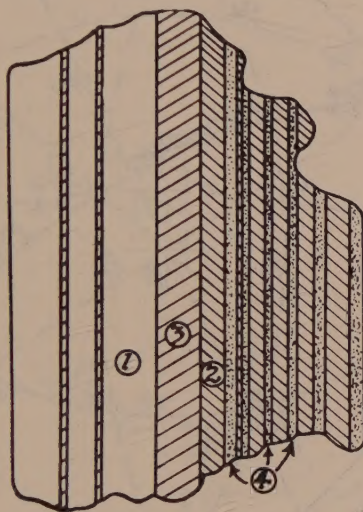


FIG. 4. The twinned feldspar used in the illustration.

clockwise to extinction. Berek's curves (solid black line in fig. 3) now indicate *for the reference position* the attitude of the optic plane and the position of the acute bisectrix. Rotate the microscope stage back to its zero position, return the outer E-W axis to its zero position, and insert the sensitive tint plate bearing in mind the position of the optic plane and the acute bisectrix as determined from fig. 3. The change in interference color of the tint plate gives the sign of the crystal and indicates definitely which direction is α , β , and γ . The sign may remain in doubt if $2V$ is near 90° , unless the corrections for 54.7° were very carefully made. Record this information as illustrated in table 1. Using a standard

(2) If the optic plane is vertical, V or 2V may be read directly in the following manner. Rotate on the stage of the microscope from the oriented position 45° either way. Then using that horizontal axis which is perpendicular to the optic plane (now known), rotate to an extinction position or to both of them if possible. The angle between these positions is apparent 2V, (or apparent V if

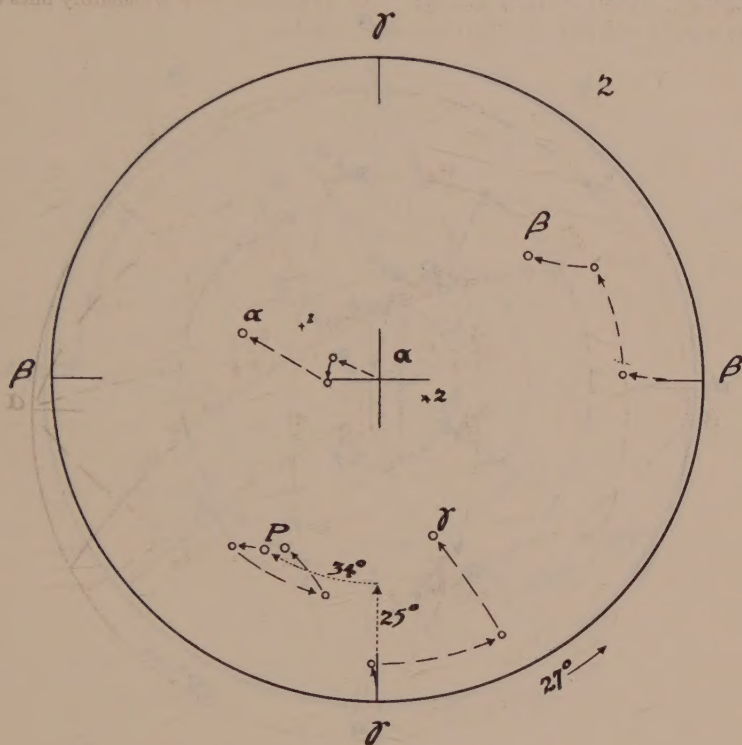


FIG. 5b.

measured from α or γ). It is to be corrected for difference in index between crystal and hemispheres as described later. It is almost always possible to measure V or 2V by this direct method in studying plagioclase when the optic plane is vertical, even when the acute bisectrix is horizontal, since 2V is never less than 70° .

If the optic plane is horizontal in the chosen position of orientation it is sometimes possible to obtain a direct reading by rotating on the N-S axis sufficiently to make the optic plane vertical (and parallel with the N-S nicol). In this position V or 2V may be read

cleavage plane vertical and parallel either to the E-W crosshair by rotation on the outer E-W and the outer vertical axes or to the N-S crosshair by rotation on the N-S and outer vertical axes. Record the values. Do the same for the composition faces of the twins. It is by no means easy to make these reference planes *accurately* parallel to the axis of the microscope in sections of standard

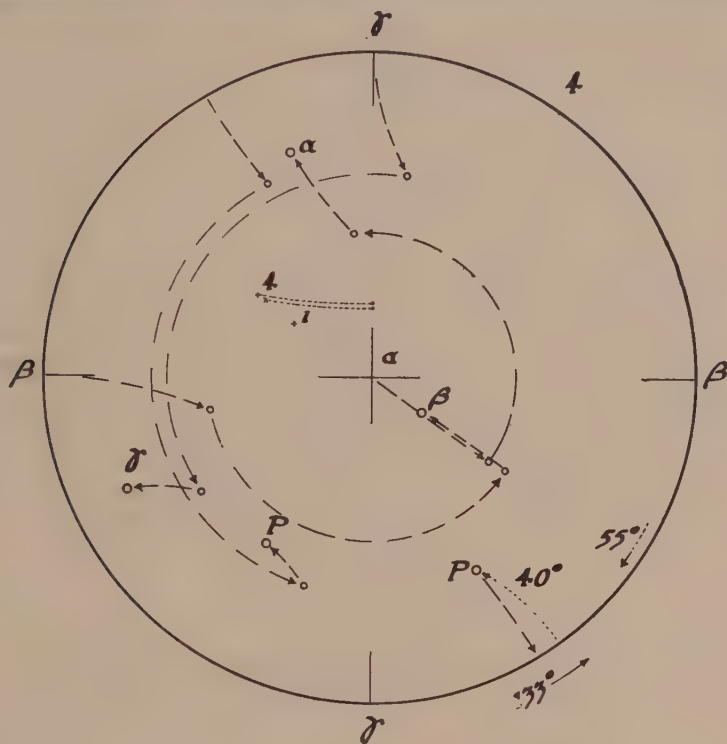


FIG. 5d

thickness. Nikitin therefore recommends using special sections as much as 0.1 mm. thick. In practice it will be found desirable for accurate work to use sections 0.06–0.10 mm. thick. The thicker the section, the broader must be the lamellae to make orientation possible. This limitation militates against the use of thicker sections than standard. Parallelism to the axis of the microscope is obtained when the line defining the plane is sharpest, that is when the plane is on edge. It is advisable to make several readings and to use an average value for the horizontal axis reading.

(4) Information thus far obtained, enables us to learn where in the crystal is α , β , and γ and where with respect to these directions are the planes of cleavage and the composition faces of the twins.

FIG. 6. Fedorov-Nikitin stereograms. (b) and (e) are the original drawings. The others are different orientations needed for the method described here. The data for the points were taken from Nikitin's recent paper (4).

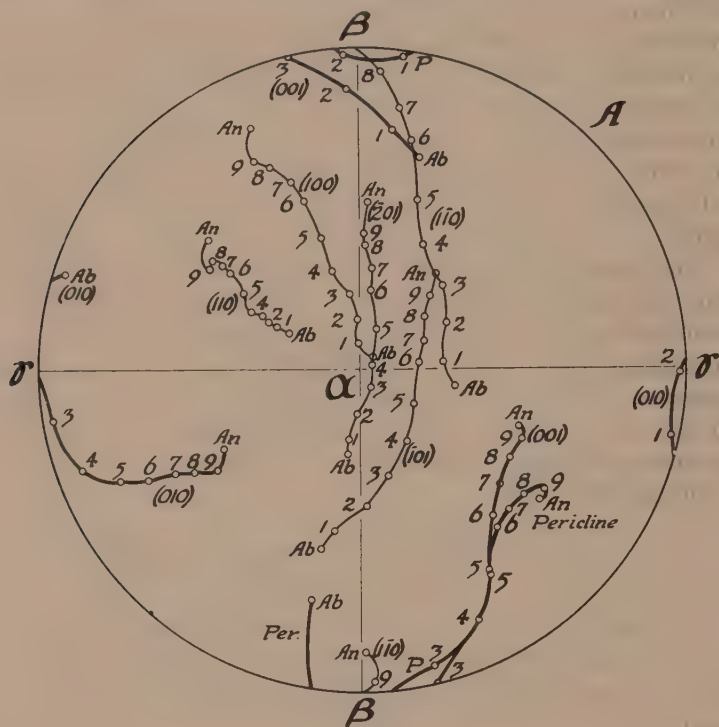


FIG. 6a.

That is, we now have enough information to indicate the relation between the optic orientation and the crystallographic orientation. Therefore on the chart (Fig. 2) on which α , β , and γ have been noted in cardinal positions, plot with corrections as given later the poles of the reference planes, and superimpose the chart on Figs. 6a, 6b or 6c according to whether α , β , or γ is at the center. The positions of the points representing the face poles, on the reference lines of the plot, indicate the anorthite content of the crystal. In actual practice the approximate composition is learned first by

plotting the pole of one face. This value gives the approximate index value, β , of the plagioclase and this is used in correcting the various rotations. In routine work only one plane (cleavage, crystal face or composition face) is used. For a check more than one is plotted.

It will be noticed that four positions of superposition are possible. The correct one is learned by trying each, and choosing that which fits. To do so (1) place the chart over the reference diagram in a position such that α , β , and γ of each properly coincide. Then (2) invert the chart by rotating 180° about one horizontal axis, α for example, assuming β to be at the center; next (3) invert again but about γ in a similar manner, and (4) invert once more about α . (A second rotation about γ would give the original position again.)

The points will not often fall exactly on the reference lines, either because of inaccurate work or because of the potash content of the crystal, or because of strain in the crystal. If a point does not fall exactly on a line, it does not necessarily indicate that potash is present, and if it does fall exactly on a line it does not indicate that potash is absent. The time required to execute the steps thus far taken is surprisingly short for an experienced operator.

An example follows:

TABLE I
UNIVERSAL STAGE DATA SHEET

Rock: *C-15-9* Locality: *Hot Point, Lake Superior*
Mineral: *Plagioclase* Zero Positions—Mic. *186.3^\circ*
Hemispheres *1.649* O.V. *90^\circ*

Unit 1:—

I.E.W.	17°N	I.V.	22°	Comp. Face	H	26.5°S
N.S. 1	26°W	α	E		V	28.5° \nearrow
2		β	\perp	Cleavage 1	H	
O.A. 1		γ	N		V	
2		Bx_a		" 2	H	
Ext.B	44°	Sign			V	

Unit 2:—

I.E.W.	7°S	I.V.	49°	Comp. Face	H	24°S
N.S. 1	16°E	α	\perp		V	34° ⁵
2		β	E	Cleavage 1	H	
O.A. 1	42°S	γ	N		V	
2	40°N	Bx_a	\perp	" 2	H	
Ext. B		Sign	—		B	

Unit 3:—

I.E.W.	28°S	I.V.	159°	Comp. Face	H	47°N
N.S. 1	7°E	α	E		V	36° ⁴
2		β	N	Cleavage 1	H	
O.A. 1	44°W	γ	\perp		V	
2		Bx_a	E	" 2	H	
Ext. B		Sign	—		V	

Unit 4:—

I.E.W.	24°N	I.V.	155°	Comp. Face	H	38°E
N.S. 1	38°W	α	\perp		V	55° ⁵
2		β	E	Cleavage 1	H	
O.A. 1	44°S	γ	N		V	
2		Bx_a		" 2	H	
Ext. B		Sign			V	

REMARKS:

*Composition face is (010)**Twins present—Albite**Carlsbad**Albite-Carlsbad Complex**Composition: 72-75% An.*

In fig. 5 the points P represent the pole of the composition face of the twin unit. Note the method of plotting the points—the values were obtained from fig. 2. When these drawings are superposed on fig. 6 it will be found that the points P fall near the line (010) at $\pm 75\%$ An. Adjacent twin lamellae need not have the same composition but are ordinarily close.⁵ Since it is intended to point out

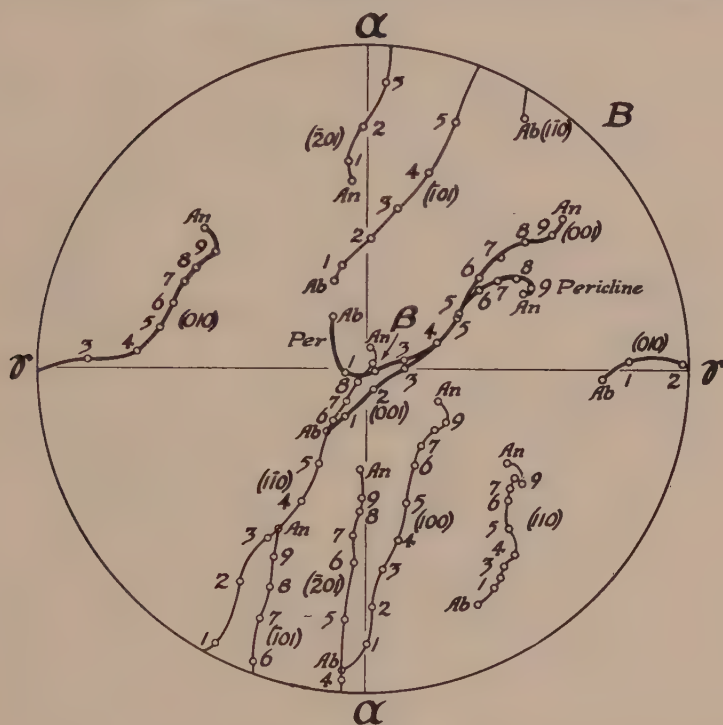


FIG. 6b.

here only the *difference* in the procedure, one example is deemed sufficient. It was selected as a typical one rather than for its completeness or perfection.

Thus far one unit of a twinned plagioclase has been studied and its optic orientation has been related to its crystallographic orientation revealing the anorthite content. We still do not know the type of twin or the position of the twin axis. When this axis is

⁵ A. L. Coulson reports differences as high as 17% An. *Rec. Geol. Surv. Ind.*, vol. 65, p. 163, 1932.

rotated (figs. 5b, 5c, 5d) to its new position, the amount of rotation being that needed to bring to the center the perpendicular to the inner stage. This yields the orientation of the crystal in the horizontal position of the thin section. If there are more than two twin members studied then all but one are so rotated. This one may be arbitrarily selected as unit one.

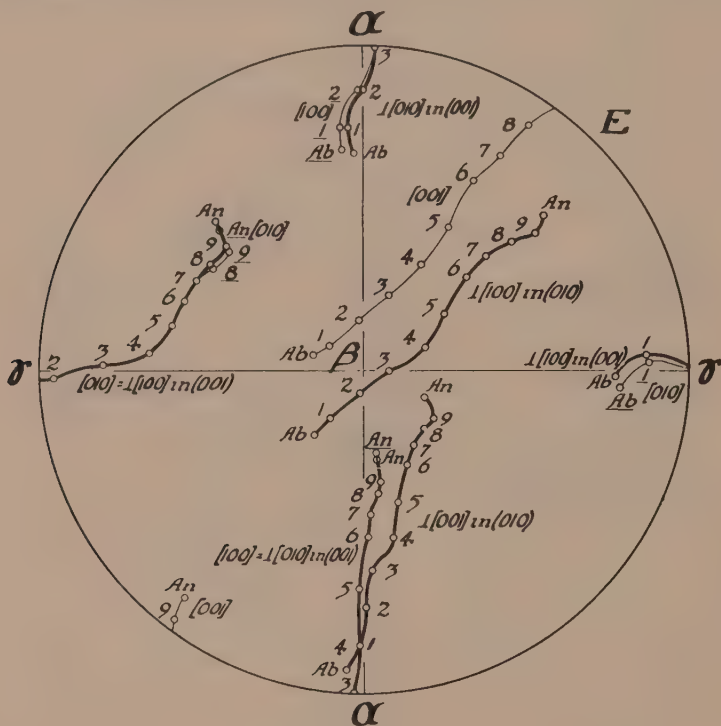


FIG. 6e.

Second, each of those so rotated is next turned on an axis perpendicular to the plane of the paper, an amount sufficient to make its orientation, crystallographically identical with that of unit one before its inclination. This amount is read directly from the graduations of the stage,—it is the difference between the inner vertical axis readings of the two units. If the reading for the second unit is less than that for unit one then the points of the second unit are rotated clockwise the proper amount, keeping their radial distance from the center the same,—and *vice versa*.

Third, the second unit is now to be inclined an amount equal to the inclination of unit one. Locate on the unit two chart the corrected position of the perpendicular to the inner stage of unit one. Each point of unit two is then rotated the amount of this radial angle. A simple way to do so is similar to step one above. Superimpose the unit two chart on a blank chart with this new point

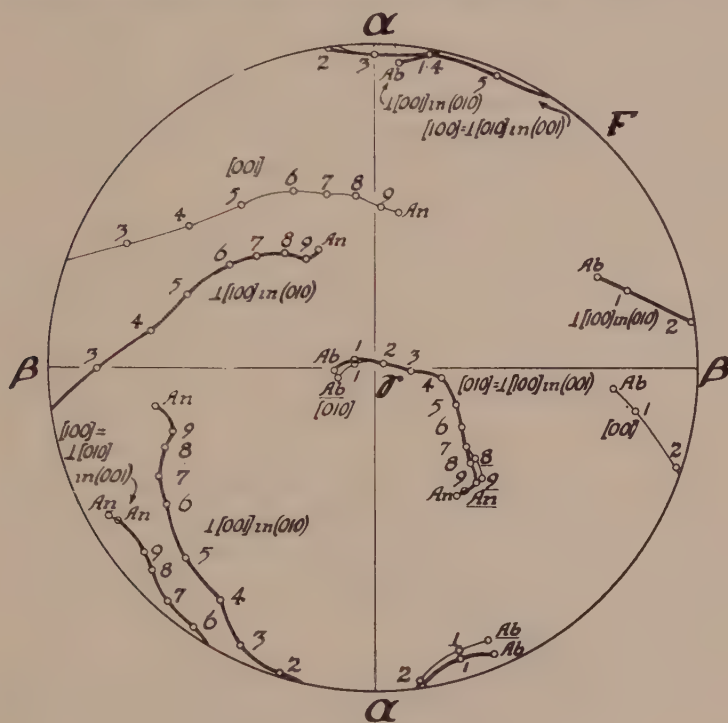


FIG. 6f.

on one of the cardinal lines. Then rotate each of the points of interest from their last found position to new positions, an amount sufficient to bring the center to the point transferred from the unit one chart. The points α , β , and γ of unit two are now so placed that this unit is in the position which it occupied when unit one was oriented; these points may now be transferred therefore to the chart of unit one and be properly labelled that there may be no confusion. (i.e., α_2 , β_2 , γ_2). Other units than the first are similarly treated and transferred to unit one. Fig. 5a therefore shows unit

one in critical orientation and units two, three and four in proper relationship to it.

Fourth, if a fundamental circle has been used throughout, as in the example, then superpose in cardinal position the unit one chart to which have now been added α_2 , β_2 , and γ_2 , etc., on fig. 2 and trace the great arcs passing through $\alpha_1 - \alpha_2$, $\beta_1 - \beta_2$, $\gamma_1 - \gamma_2$, $\alpha_1 - \alpha_3$, etc. These great arcs will indicate by their points of intersection the twinning axes. They delimit a small triangular area—theoretically a point—at the center of which a point is chosen—it is the twinning axis. Unit 4 is narrow (see fig. 4), a difficult type to orient accurately since large rotations on horizontal axes cannot be made. The orientation of this unit is not so accurate as the others but it illustrates a common difficulty.

The twinning axis lies either in the composition plane or 90° to it. If it is perpendicular to it, coinciding with the pole of the plane, the twin is a normal twin; if it lies within the composition plane the twin is a parallel or complex twin. Seldom does the axis fall ideally in position but it should lie reasonably close to it. Errors of reading, especially of the positions of twin or composition planes, and “errors” due to the presence of K_2O cause discrepancies. The plot is now superimposed over the proper reference plot (figs. 6d, 6e, 6f) and the axis of twinning falls on a line after proper adjustment as was done for the pole of cleavage, indicating thereby the twin law (which the line represents) and the anorthite content (which points on the line represent). Commonly the point representing the twin axis does not fall exactly on the line due to the discrepancies mentioned above.

The corrections are best explained with the aid of an example. In fig. 5c the perpendicular to the inner stage is $28^\circ S$ and $7^\circ E$. These values are to be measured in this order since the axis I.E-W is dependent on the axis N-S. The radial angle is measured next (28°) and corrected for the difference in index of the feldspar (1.57) and the hemisphere (1.649) to 29.7° using Fedorov's diagram. The composition plane of unit three is given as $47^\circ N$ and 36° clockwise on 0.V. from the oriented position. The correction is made on the position of the perpendicular to the inner stage. From both positions “X” and “+” on fig. 5c, measure 36° counter-clockwise. From the new position of “X” measure 47° north along the proper great arc as indicated by the dotted line. Correct the radial angle of

this last found position, and measure the angle south to the corresponding corrected point. It is 50° .⁶

To locate the pole P, measure from the north pole 50° south—the reverse of the original reading,—and 36° counter-clockwise—also the reverse of the original reading. This locates P when the axes O.V. and O.E-W are at their zero readings.

In the readings for the composition face of unit 4 (fig. 5*d*) the N-S crosshair was used and therefore the axis N-S, which is dependent on the axis O.V. To correct the reading 38° E therefore do not measure 55° counter-clockwise first from the perpendicular to the inner stage (marked "4") but measure 38° E directly as indicated and correct the radial angle. The corrected points indicate a rotational value of 40° E. Note too the difference in locating P. First measure 55° clockwise from the east pole—the reverse direction of the original reading and then measure 40° parallel to the proper arc as indicated by the dotted line. If the positions of the axes are kept in mind there will be no confusion. In general the student's greatest difficulty is encountered in handling the corrections.

SUMMARY OF PROCEDURES

1. Orient a twin unit of a chosen crystal, record the scale readings of the axes I.V., I.E-W and N-S.
2. Orient a cleavage plane, or composition face, etc., and record the scale readings.
3. Determine the positions of the optic plane and acute bisectrix (the sign and $2V$).
4. Plot α , β and γ on a suitable chart or preferably on a circle to fit an accompanying Fedorov net. Here they will fall one at the center, one north (and south) and one east (and west).
5. Correct readings made on horizontal axes for the pole of the chosen plane, plot them and fit the plot to the proper reference

⁶ In the references (2) and (5) corrections are made on a stereographic net over which a system of square coordinates was placed instead of following the more accurate, outwardly concave great arcs. For corrections of the type made in those papers an introduced error virtually cancels itself, since only the center of the drawing was used, and the advantage of following straight lines remains. In the writer's laboratory this has been given up for the gnomonic net which also has one set of straight lines. If the Fedorov net is not found confusing, it may be used for all these purposes.

diagram. This is sufficient to give the composition of the plagioclase.

To determine the twin law:

6. Orient a second unit of the twin and any others present recording the values as in table I. Make the necessary corrections and plot the results on separate sheets.

7. Rotate all but unit one through three movements to bring them to the orientation they assumed when unit one was critically oriented.

8. Draw the great circles to locate the twin axes.

It may be noticed that in fig. 5a the great circles through $\alpha_2 - \alpha_3$, $\alpha_2 - \alpha_4$, $\alpha_3 - \alpha_4$ and similarly for β and γ have been omitted to avoid confusion of lines. They indicate the same axes as suggested by the notations on the figure.

It is obvious that the principles underlying this type of study are especially useful in studying feldspars mainly because of the comparative wealth of data available. In principal the technique is equally effective in the study of other minerals, but data are frequently lacking. For those minerals in which optic orientation is a good diagnostic criterion, this is especially well adapted, and there are many such.⁷

⁷ When this paper was presented at the Chicago meeting of the Mineralogical Society, Professor E. S. Larsen expressed doubt about the possibility of adjacent twin lamellae being different in composition. Although the writer entertains no such doubts he considers Professor Larsen's comments pertinent. A hurried preliminary test was run on a plagioclase crystal from the anorthosite at Beaver Bay, Lake Superior. This rock was chosen because of the breadth of its twin lamellae. The indices of adjacent lamellae in the crystal studied are:—(1) $\alpha = 1.5666$, $\beta = 1.5718$, $\gamma = 1.5757$; (2) $\alpha = 1.5659$, $\beta = 1.5707$, $\gamma = 1.5759$ ($\pm .0003$). These values are not at all startling but are adequate to indicate a real difference in composition—in this case 2–3% An. It is proposed to study this point thoroughly and to report briefly later.

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SECONDARY MONTMORILLONITE IN A CALIFORNIA PEGMATITE

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ABSTRACT

Portions of a southern California pegmatite have been replaced by a clay mineral. The original material appears to have been chiefly feldspar, and the clay mineral has the chemical composition and the optical and x-ray properties of montmorillonite.

OCCURRENCE

There is an abandoned quarry about 2 miles north of Claremont, Los Angeles County, California, at the head of Indian Hill Boulevard and 0.6 mile north of the San Bernardino base line. The quarry is in weathered bedrock at the very base of the south slope of the San Gabriel Mountains. The rocks exposed in the quarry are rotten quartz-biotite schist dipping gently southwest, and rather fine-grained pegmatite in bands a foot or two thick and roughly parallel to the schistosity of the country rock. The pegmatite is composed of abundant quartz, orthoclase and albite, with rare biotite. Most of the feldspar is dull and cloudy. The feldspar crystals range from $\frac{1}{2}$ to 10 mm. in diameter; small feldspars may occur together, making somewhat larger masses. At the northeast end of the quarry in its present (1933) condition part of a pegmatite band, shown in fig. 1, is entirely made up of white to very pale buff clay, containing scattered quartz grains. This part of the quarry is about 20 feet below the original, sloping surface of the ground. That surface was covered by dense chaparral, and roots extend to a measured distance of 22 feet below the surface and probably farther, penetrating here and there the clay zone shown in fig. 1, but not notably abundant in it.

The irregular, branching clay zone occupies the upper part of a pegmatite band, just beneath rotten schist, and averages 1 or 2 inches in thickness. It shows little or no evidence of fault slip or vein filling, but is merely a completely altered portion of the pegmatite. Toward the margin of the zone there is more and more pink feldspar embedded in the clay. The fairly firm pegmatite adjacent to the clay zone contains small, irregular areas of the clay mineral. Thin sections were prepared from partially weathered pegmatite collected at the edge of a downward extension of the

clay zone. With a magnification of 1800 diameters it was seen that the cloudiness of the orthoclase and albite is chiefly due to elongated cavities 1 to 12 microns in length. In some cases the cavities are parallel to the cleavages. Some inclusions of mica and other minerals were seen, but no clay mineral. It is concluded that the clay mineral (montmorillonite) is not the result of particle by

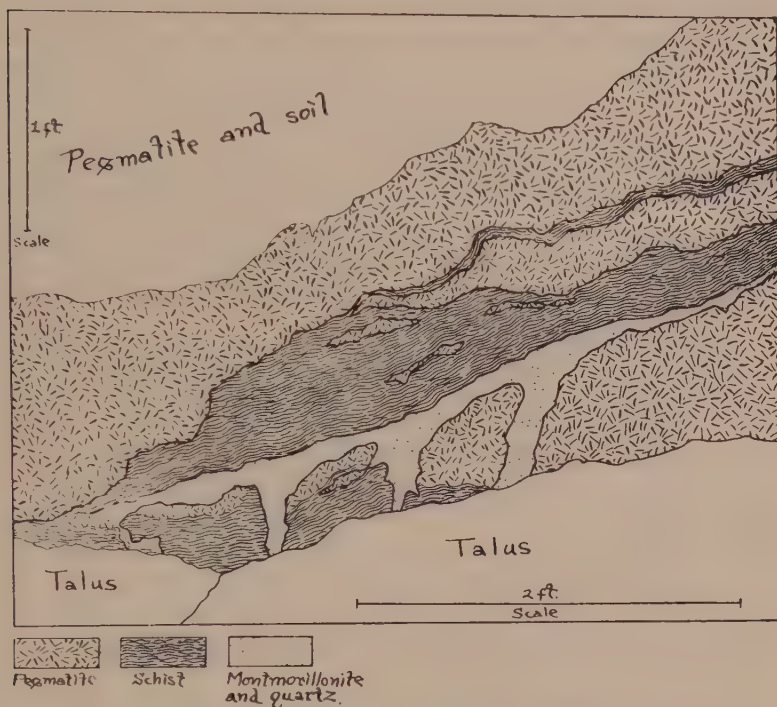


FIG. 1. Sketch showing occurrence of montmorillonite, Claremont, California.

particle alteration of feldspar in place, though it may be that new crystals of montmorillonite have grown in space vacated by the wasting of the feldspars. Perhaps the absence of vein or geode or other regular structures in the clay is entirely due to its softness, but in this connection it should be noted that no veinlets of montmorillonite were seen, even in crumbly, porous feldspar.

The purest clay was found to have a waxy appearance. Waxy material to the amount of 2 or 3 grams was picked out by hand for further study.

OPTICAL PROPERTIES

The selected material was judged from microscopic examination (by Woodford) to be almost entirely one mineral, even though the indices were not absolutely uniform throughout. The only impurities recognized were 3 or 4 small bits of altered feldspar and biotite, and the total impurities exclusive of iron stain were estimated to be less than 1%.

The clay mineral occurs as a tangled mass of very small, flexible plates, which are 5 or 10 or at most 40 or 50 microns across. There is probably basal micaceous cleavage. Plates lying flat are practically isotropic. Plates on edge show interference tints up to second order blue-green, indicating a birefringence of .015. Extinction is usually parallel or nearly so, with positive elongation, but several plates with slightly inclined extinction were seen, and one with 20° extinction angle and negative elongation. This last grain is presumably an impurity. It is thought that in most cases X is nearly perpendicular to the cleavage.

The indices of refraction of the air-dried material used for analysis were determined in oils with white light, and the oils calibrated with a Spencer Abbe refractometer, which was in turn checked by test plates. Beta and gamma are commonly $1.491 \pm .002$, exceptionally as high as $1.496 \pm .002$, very rarely as high as $1.510 \pm .003$. Alpha is some .015 lower, commonly $1.475-1.480 \pm .002$. After standing 5 days over 52% H_2SO_4 to give a definite water vapor pressure, the indices became more uniform, beta and gamma $1.490 \pm .002$; alpha $1.475 \pm .002$. A comparison of these indices with those of other examples of montmorillonite is shown in Table I.

TABLE I. OPTICAL PROPERTIES OF MONTMORILLONITES

	alpha	beta and gamma	$\gamma - \alpha$	2V
Claremont, Calif. (Woodford)	1.475 up	1.490-1.510	.015	—
Otay, Calif. (otaylite) (Woodford)	1.468-1.485	1.487-1.500	.019	very small
Otay, Calif. (otaylite) (Ross & Shannon, 1926, p. 95)	1.492	1.513	.021	16°-24°
Montmorillon, France (Ross & Shannon, 1926, p. 96)	1.503	1.527	.024	—
France (Montmorillon?) (Kerr, 1932, p. 197)	1.485	1.506	.021	—

The white otaylite, after standing 48 hours over 52% H_2SO_4 , gave values of 1.468 for alpha, and 1.487 for beta and gamma. We do not understand the causes for the variations in montmorillonite indices shown by Table I. The differences may be connected with the amount of water present. Kerr (1931, p. 161) reports that the values for moist bentonite from Ventura, California, were alpha 1.470, gamma 1.481, and after air-drying, alpha 1.510, gamma 1.532. However, the Claremont montmorillonite is not unusually high in H_2O .

CHEMICAL COMPOSITION

Spectrographic analysis (by Dr. T. G. Kennard of Claremont Colleges) showed the presence of abundant Al and Si, some Mg, little Na and Fe, and traces of Cu, Ca and Ti.

A single chemical analysis was made (by Laudermilk) with results shown in Table II, C.

TABLE II. CHEMICAL ANALYSES OF MONTMORILLONITES

	A	B	C	D
SiO_2	48.60%	50.30%	49.70%	.8275
TiO_2	—	—	0.28	.0035
Al_2O_3	20.03	15.96	22.10	.2168
Fe_2O_3	1.25	0.86	2.12	.0133
MnO	0.16	—	Trace	—
CaO	1.72	1.24	1.08	.0193
MgO	5.24	6.53	2.85	.0707
K_2O	—	0.45	None	—
Na_2O	—	1.19	1.17	.0189
P_2O_5	—	—	None	—
H_2O	21.52	23.61	21.14	1.1734
Total	98.52%	100.24%	100.44%	

- A. Montmorillonite, Montmorillon, France. Earl V. Shannon, analyst (Ross & Shannon, 1926, p. 90).
 B. Bentonite (otaylite), crude selected white material near Otay, San Diego Co., Calif. J. E. Whitfield, analyst (Ross & Shannon, 1926, p. 88). Slightly in error as given, for constituents add up to 100.14%.
 C. Montmorillonite, Claremont, Calif. J. D. Laudermilk, analyst.
 D. Molecular ratios of C.

Comparison with the other analyses of Table II shows that the Claremont montmorillonite is somewhat high in alumina and low

in magnesia. The molecular ratio of SiO_2 to Al_2O_3 is 3.8 as compared to the typical ratio of 5 suggested by Ross and Shannon (1926, pp. 87, 89). The formula of the Claremont mineral might be written $(\text{Mg,Ca})\text{O} \cdot 2\text{Al}_2\text{O}_3 \cdot 8\text{SiO}_2 \cdot 12\text{H}_2\text{O}$, as compared with the formula $(\text{H}_2,\text{Mg,Ca})\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 5\text{SiO}_2 \cdot 5-7\text{H}_2\text{O}$ suggested for montmorillonite by Ross and Shannon (1926, p. 89).

X-RAY EXAMINATION

Through the kindness of Dr. W. P. Kelley and Mr. W. H. Dore of the University of California we are able to give the results of an x-ray examination of the Claremont clay. Mr. Dore determined the x-ray powder spectrum, and obtained its intensity curve, as given by a Zeiss Photo-electric Recording Photometer, from the University Department of Physics. Otay bentonite (otaylite) was used for comparison, with results shown in Table III and Fig. 2.

TABLE III. X-RAY COMPARISON OF CLAREMONT CLAY AND OTAYLITE

Claremont						Otay		
Light exposure (No. 1334)			Over-exposed (No. 1376)			Over-exposed (No. 1375)		
Dist. to zero line, cm.	Corr. spacing Å	Inten- sity peaks	Dist. to zero line, cm.	Corr. spacing Å	Inten- sity peaks	Dist. to zero line, cm.	Corr. spacing Å	Inten- sity peaks
2.85	5.0	54.5	2.85	5.0	48	2.85	5.0	50
3.23	4.4	59.5	3.23	4.4	50	3.23	4.4	52.5
4.75	3.03	51	4.80	3.0	46	4.8	3.03	48
5.15	2.80	45						
5.65	2.56	52	5.65	2.56	47	5.65	2.56	48.5
6.4	2.26	44	6.4	2.26	42	6.5	2.23	43
6.7	2.17	43	6.6	2.20	42			
7.55	1.92	37.5						
8.05	1.80	35						
8.2	1.77	35						
8.6	1.69	40.5	8.65	1.68	39.5	8.6	1.69	41
9.7	1.50	46	9.75	1.495	43	9.75	1.495	44.5
11.3	1.295	36	11.35	1.29	38	11.3	1.295	39
11.7	1.25	33	11.8	1.24	36	11.7	1.25	36

Notes: The columns headed "corresponding spacings Å.," represent only approximate values for the interplanar spacings, but are nevertheless in satisfactory agreement with more accurate measurements made upon original *x*-ray films and with data which are already in the literature. The heights of the intensity peaks, given under that heading in the table, have only comparative value, e.g., as between Nos. 1375 and 1376, which were on the same original film. No. 1334 is added because over-exposure snubbed the first peak intensities for 1375 and 1376 and obscured other lines.

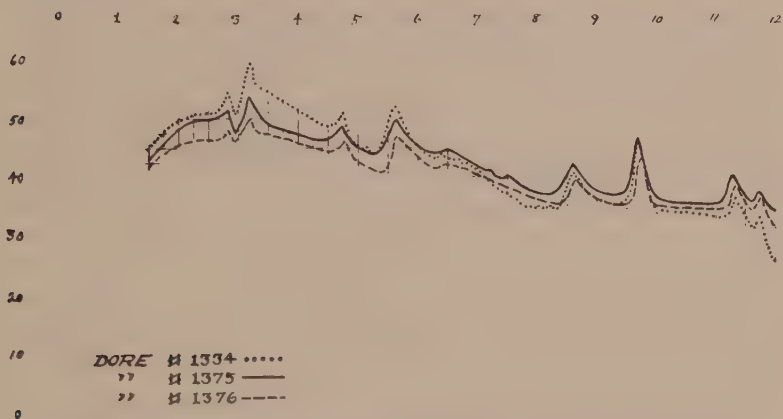


FIG. 2. X-ray intensity curves for Claremont (1334, 1376) and Otay (1375) montmorillonites. Abscissas: cms. to zero line; ordinates: relative intensities.

Mr. Dore furnishes the following notes: "Spacings 1.115, 1.02 and 0.97 Å., observed on the original *x*-ray films, were represented on the intensity curves by broad or irregular humps, and the exact positions of the peak intensities cannot be given. On the other hand, a small intensity peak occurs at about 6.5 cms., corresponding to 2.26 to 2.17 Å. This spacing was not observed on the original *x*-ray films 1334, 1375 and 1376, but similar spacings have been observed in other montmorillonite patterns, both in the original *x*-ray films and as peaks on their intensity curves, leaving little doubt that this spacing should be included in the characteristic list for montmorillonite. The sharp intensity peak at 5.65 cms., corresponding to 2.56 Å., makes definite a spacing value previously reported as a broad band on the original *x*-ray films, corresponding to a spacing between 2.60 and 2.48 Å. The photometric work confirms our original conclusion as to the identity of your material with montmorillonite."

DISCUSSION

If one may judge from Lacroix's description (1895, p. 482) the montmorillonite at the type locality occurs in sedimentary rocks. The numerous well-established occurrences of montmorillonite described in recent years (e.g., by Ross and Shannon, 1926) are practically all in bentonite. The mineral may also be formed by solfataric action (Ross and Kerr, 1931, p. 62). Ross and Shannon (1926) mention 3 possible pegmatite occurrences, one at the type locality, a second in New Mexico and a third in Connecticut. As to the first mentioned case, a communication from Dr. Ross states that Ross and Shannon wished to emphasize the fact that in all observable properties the material from the type locality is identical with the montmorillonite from pegmatites. They did not intend to state that it came from an altered pegmatite. The New Mexico example was not discussed by Ross and Shannon in any detail. The Connecticut locality was fully described long ago by Brush and Dana (1880). They found spodumene altered to "cymatolite," a mixture of albite and muscovite, and (p. 283) montmorillonite associated with partially altered spodumene and with "cymatolite" and also as independent masses in the pegmatite.

Schaller (1905) analyzed pink halloysite from a Pala, California, pegmatite. After optical study, Ross and Shannon (1926) referred to this material as crystalline "halloysite." It differs chemically from montmorillonite, but is similar optically. It has been suggested (Eakle 1923, p. 223) that some of the Pala pegmatite clay may be montmorillonite. Schaller in a later paper (1925, p. 273) perhaps implies for this clay an origin by weathering rather than by hydrothermal action.

In the fine-grained, uniform Claremont pegmatite there is no reason to suspect the former presence of spodumene or other rare minerals. It is more probable that feldspars furnished the principal part of the substance of the clay, as suggested above. We think that the mode of occurrence and the absence of any evidence of hydrothermal alteration establish our case as one of weathering.

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SEARLESITE FROM ESMERALDA COUNTY, NEVADA¹

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INTRODUCTION

The mineral searlesite was first described by Esper S. Larsen and W. B. Hicks² from well boring samples from Searles Lake, California. It occurred in the muds of this deposit of salts as nearly white spherulites of minute size, made up of radiating fibers, intimately mixed with calcite, sand and other impurities. Material much better suited for investigation, was later found in the Silver Peak Range, Esmeralda County, Nevada. This was studied by Austin F. Rogers,³ who determined the essential crystallographic constants and more accurate optical properties of this mineral. The writer visited the locality in company with Mr. Forest Gonyer, in the summer of 1929 and collected a quantity of material sufficient for a more thorough study of the mineral, including a complete chemical analysis of the satisfactorily pure mineral.

CHEMICAL PROPERTIES

Material for analysis was obtained by scraping the clear glassy crystals from their matrix and removing hyalite and barite by means of heavy solutions. The sample thus obtained consisted of broken fragments of clear crystals without visible admixture of other substances when examined under the petrographic microscope. The boron was determined by titration with standard

ANALYSIS OF SEARLESITE, CAVE SPRINGS WASH, NEVADA

W. F. Foshag, analyst

		Theoretical Composition
(Fe, Al) ₂ O ₃	0.44	
CaO	0.32	
Na ₂ O	14.60	15.20
K ₂ O	0.17	
B ₂ O ₃	17.28	17.15
SiO ₂	58.80	58.82
H ₂ O	8.90	8.83
	100.51	

¹ Published with the permission of the Secretary of the Smithsonian Institution.

² *Am. Jour. Sci.*, vol. 38, pp. 437-440, 1914.

³ *Am. Jour. Sci.*, vol. 7, pp. 498-502, 1924.

sodium hydroxide solution, after removal of the silica by evaporation to dryness. The bases were determined in the usual manner after removal of boric acid by volatilization with hydrochloric acid and methyl alcohol. The results are given in the above table.

The analysis agrees closely with that required for the formula: $\text{Na}_2\text{O} \cdot \text{B}_2\text{O}_3 \cdot 4\text{SiO}_2 \cdot 2\text{H}_2\text{O}$, the formula proposed by Larsen and Hicks from their analysis of the impure mineral.

The mineral is easily soluble in hydrochloric acid, which solution gives the usual reaction for boric acid and silica. Before the blow-pipe, the mineral whitens, intumesces and finally fuses to a colorless glass. It gives a strong sodium flame.

CRYSTALLOGRAPHY

The crystals of searlesite are small, seldom exceeding 3 millimeters in length. They are all prismatic and quite simple in their forms. A number of crystals have undergone partial resolution with the development of several faces more or less vicinal in character. No twins were observed.

The crystals, although appearing to the eye to be eminently suitable for measurement were found to give rather poor signals so that the measured angles are not of the best quality. The domal faces while small gave satisfactory readings but the prism zone usually showed blurred images. Seventeen crystals were measured on the two circle goniometer and a number of others mounted for examination but discarded without complete measurement. Five well defined forms and two solution forms were noted.

Elements. The angles used in the calculation of the elements of crystallization were those of the forms $m(110)$, $r(101)$ and $s(\bar{1}01)$. For the angle ϕ of the prism only those measurements marked "good" in the notebook were used. These ranged from $\phi = 41^\circ 21'$ to $42^\circ 12'$, average of all was $41^\circ 49'$. For the dome faces all measurements were used, the good faces were given twice the value of the poor ones in the general average. The ρ angles varied for $s(\bar{1}01)$ from $34^\circ 19'$ to $34^\circ 48'$, average of $34^\circ 28'$; for $r(101)$ from $49^\circ 4'$ to $49^\circ 42'$, average $49^\circ 25'$. From these measurements the following constants were calculated:

$$\begin{array}{llll} e = .2338; & p_0 = .9012; & q_0 = 1.0126; & h = .9723 \\ a = 1.1503; & c = 1.0367. & \mu = 76^\circ 29' \end{array}$$

Rogers has determined the following constants from the measure-

ment of two crystals: $a=1.148$, $c=1.034$, with which the above values are in fair agreement.

Forms and Angles. Five definite forms and two solution forms were found on the searlesite crystals. These are the two domes $r(101)$, and $s(\bar{1}01)$; the prism $m(110)$; and the pinacoids $a(100)$ and $b(010)$. The solution forms have approximately the indices 7.12.4 and 405.

MEASURED AND CALCULATED ANGLES, SEARLESITE

Lt	Symbol	No. of crystals	No. of faces	Measured		Calculated	
				ϕ	ρ	ϕ	ρ
a	100	17	34	90° 00'	90° 00'	90° 00'	90° 00'
b	010	2	4	0 00	90 00	0 00	90 00
m	110	17	68	41 49	90 00	41 49	90 00
r	101	10	10	90 00	49 25	90 00	49 25
s	$\bar{1}01$	11	11	90 00	-34 28	90 00	-34 28
	7.12.4 (?)	3	5	25 32	72 40	23 59	75 25
	405 (?)	2	2	90 00	-28 45	90 00	-26 48

$a(100)$. The width of the orthopinacoid varies and was observed on all the crystals. It is sometimes deeply striated.

$b(010)$. This form is usually absent but may be found on some of the larger crystals as a very narrow to line face.

$m(110)$. The unit prism is always present and has always about the same relative size. The faces are smooth and without striations but the reflections are often blurred.

$r(101)$. The front orthodome is always present and is the largest terminal face on the crystals. It often reduces the rear orthodome to a very small face or suppresses it entirely.

$s(\bar{1}01)$. The rear orthodome is usually present but is sometimes absent or too small to measure. Both the orthodomes are sharp faces and if large enough give satisfactory signals.

The form 7.12.4 results from the etching and partial solution of the crystals and is seen on large crystals. It is often large enough to give the crystals a tapering termination. The face is somewhat rounded and etched so that satisfactory measurements were not obtained. A second solution face, lying in the zone of the orthodomes, was noted on several crystals but signals from these faces were very faint and blurred. It has approximately the indices 405.

HABITS

The habits of the crystals depend largely upon the presence or absence of the orthopinacoid and its relative size. When this face is broad the crystals are lathe-like as shown in fig. 1. If narrow, the

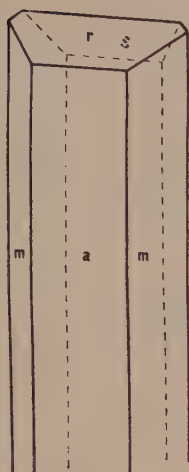


FIG. 1.

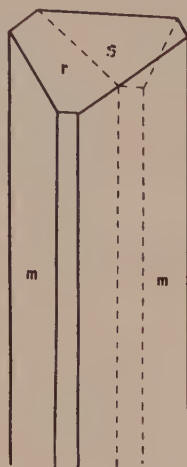


FIG. 2.

FIGS. 1 and 2. Common crystal habits from Cave Springs Wash,
Esmeralda Co., Nevada.

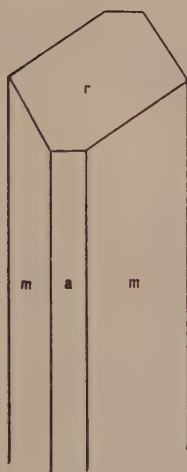


FIG. 3.



FIG. 4.

FIG. 3. Crystal habit of searlesite with prominent orthodome.

FIG. 4. Crystal habit of searlesite showing prominent solution face.

the crystals are more nearly rectangular prismatic as in fig. 2. The other variations in habit are brought about by the relative size of the front orthodome. Usually this face is somewhat larger than the rear orthodome, but a number of crystals show this face very much larger than the corresponding rear face or even forming the entire crystal termination. This latter habit is illustrated in fig. 3. Another variation of the habit is brought about by the prominent development of the steep 7.12.4 face, then the crystals have a tapering termination as shown in fig. 4.

PHYSICAL AND OPTICAL PROPERTIES

The crystals of searlesite are entirely colorless. The luster is glassy or slightly pearly on the cleavage surface. A perfect cleavage follows the orthopinacoid (100). Hd. 3.5, G. 2.44.

The indices of refraction, as measured by oil immersion method are: $\alpha = 1.515$, $\beta = 1.533$, $\gamma = 1.535$.

The indices are practically the same as those given by Rogers but differ from those given by Larsen and Hicks for the original Searles Lake material. This latter material however, was hardly suitable for accurate determinations of the optical constants, being in minute pellets and intimately mixed with extraneous material. The plane of the optic axis is normal to the orthopinacoid (100), with the orientation $b = \gamma$, $\alpha \wedge c = 34^\circ$. This extinction angle is slightly larger than that found by Rogers; $30^\circ 15'$.

OCCURRENCE

The searlesite is found in a series of thinly bedded marls that form a part of a somewhat boraciferous series of shales and sandstones flanking the Silver Peak Range on the northwest. These beds are probably a continuation of the sedimentary beds exposed along the northern end of the Silver Peak Range, believed to be of Miocene age and named by H. W. Turner,⁴ the Esmeralda Formation. This formation carries in places thin beds of coal and in others abundant remains of fish. Nearby beds, presumably a part of this same series, carries a sparse vertebrate fauna indicative of an upper Miocene or Lower Pliocene age. At a few places in the boraciferous series are small bodies of ulexite of no commercial importance.

⁴ The Esmeralda Formation, a Fresh-water Lake Deposit: *U. S. Geol. Survey, 21st. Ann. Rept.*, pt. 2, pp. 191-208, 1899-1900.

To reach the searlesite locality one follows the Coaldale-Almondale road through Fish Lake valley to a point about 2 miles south of a small hill that rises out of the valley at the south end of the saline playa in Fish Lake valley. At this point an old road leads to the east and follows up Cave Springs Wash as far as Cave Springs. About a mile below Cave Springs the road cuts across the belt of boraciferous beds, which can be easily recognized by their light color and thin fissile character. To the north of the wash on the east slope of a low ridge are a few short adits driven into the deposit to prospect the marls for borax ore.

A large part of the marls exposed in the vicinity carry some boron, the material being an intimate mixture of searlesite with carbonates of lime and magnesia and opal. An analysis of a pure white, porcelaneous marl gave the following analysis:

ANALYSIS OF BORACIFEROUS MARL, CAVE SPRINGS WASH, NEVADA

W. F. Foshag, analyst

Al ₂ O ₃	1.10
CaO	12.04
MgO	7.47
N ₂ O	9.84
K ₂ O	0.09
B ₂ O ₃	8.51
SiO ₂	39.80
CO ₂	14.48
H ₂ O	7.40
<hr/>	
Total	100.73

The crystals of searlesite are found in a banded white to pale buff or pale grayish blue marl in which the only conspicuous mineral, even with a hand lens, is a pale brown mica. There are also minute pockets of crystals and massive granular searlesite embedded in the matrix. The best crystals, however, form pockets or crusts in the transverse cracks of the marl. These crystals are seldom more than 2 millimeters in length, are clear and glassy and might easily be mistaken for gypsum crystals. Unlike gypsum, however, they are brittle and cannot be bent as small gypsum crystals can. Occasionally the crystals are not glassy but have a superficial milky coating and carry small attached beads of clear glassy hyalite.

The most common associated mineral is the hyalite already re-

ferred to. In some specimens these small beads of opal are fairly abundant. In some of the cracks there are radiating groups of small honey brown crystals of barite that are later than the searlesite. Rarely do the cracks contain an amber yellow calcite filling, and small fern-like splotches of manganese oxide are not uncommon.

ORIGIN

The Esmeralda Formation carries a curious and varied assemblage of sedimentary rocks, including beds of organic origin (coal beds), lacustrine deposits (marls containing fish remains), sub-aerial deposits (sandstones with vertebrate fossils, and fan-glomerates), abundant volcanic products (tuffs, etc.), as well as playa beds (boraciferous shales and marls). Some of the latter show silicified bands with a retention of the original bedding. This, together with the occurrence of hyalite, suggests that the original material contained a fair content of volcanic ash. It is here suggested that the action of boraciferous water of a playa on the soluble silica of volcanic ash would yield a deposit of the nature of the Cave Springs searlesite marl.

CRYSTALLOGRAPHIC ORIENTATION OF SODIUM MOLYBDO-TELLURATE*

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The description of sodium molybdo-tellurate crystals by Donnay and Mélon appeared in a recent issue of this journal.¹ We found that, besides the orientation chosen by these two authors, there exists another one, which has the advantage of bringing out the tetragonal pseudo-symmetry of the crystals. This orientation is easily found by applying the rules given by Fedorov.² According to his method, a crystal description is summarized in a so-called "complex symbol"; the latter may be written as follows for sodium molybdo-tellurate:

$$\begin{array}{rcl} 40 & +14 & 7 \\ & 46; & -18 \\ & - & 1 \end{array}$$

The following information can be obtained from mere inspection of the above "complex symbol": (1) the unit-cell is pseudo-tetragonal; (2) the unit-cell is body-centered; (3) according to Fedorov's terminology, the crystal is "negative," as indicated by the small value of the "principal number" (46°), and it is to be expected that the crystals are elongated parallel with the pseudo-tetragonal axis. That very habit is illustrated by the clinographic projection given by Donnay and Mélon.³

The orientation according to Fedorov's method is given here (Fig. 1). It can be derived from the morphological orientation of Donnay and Mélon⁴ by applying⁵ the transformation: $\bar{1}\bar{1}0/111/001$.

* Translated from the Dutch by J. D. H. Donnay.

¹ Haiiy-Bravais lattice and other crystallographic data for sodium molybdo-tellurate, *Am. Mineral*, vol. 18, pp. 225-47, 1933.

² E. von Fedorov: *Das Krystallreich*.

³ *Op. cit.*, Fig. 7, p. 245.

⁴ *Op. cit.*, Projection VI, Fig. 6, p. 243.

⁵ The transformation determinant is written in the abbreviated form: $uvw/u'v'w'/u''w''w''$. The new face-symbol (pqr) is derived from the old one (hkl) by the formulae:

$$\begin{array}{l} p=u \quad h+v \quad k+w \quad l, \\ q=u' \quad h+v' \quad k+w' \quad l, \\ r=u'' \quad h+v'' \quad k+w'' \quad l. \end{array}$$

The new axial elements are:

$$a:b:c = 1.1214:1:0.7583$$

$$\begin{array}{lll} \alpha = 78^{\circ}3'; & \beta = 82^{\circ}37'; & \gamma = 87^{\circ}23', \\ A = 101^{\circ}43', & B = 97^{\circ}0', & C = 91^{\circ}7'. \end{array}$$

The squares of the reticular densities for the various forms have been determined by the partially graphical method of Sokolov

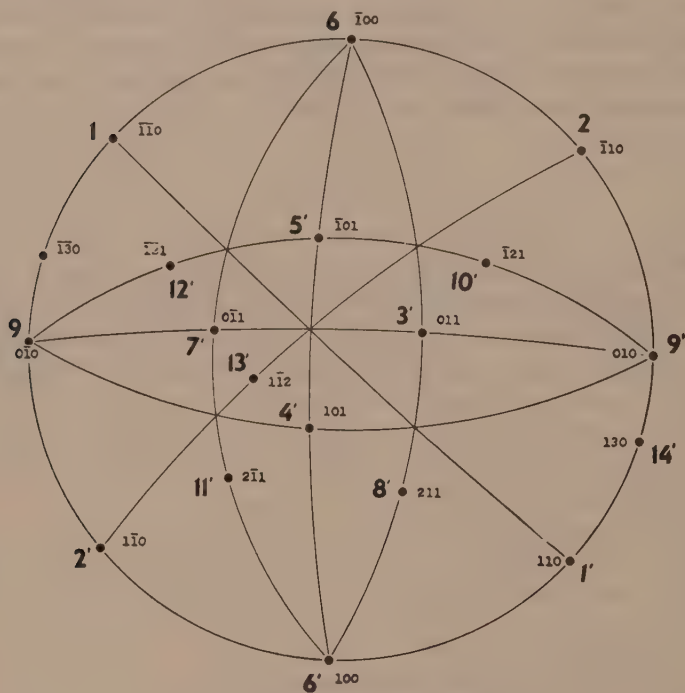


FIG. 1. Sodium-Molybdo-Tellurate.

and Artemiev. Observe that the square D^2 of the reticular density is inversely proportional to the square S^2 of the reticular area given by Donnay and Mélon in their Table 2.

The Fedorov orientation, as well as that of Donnay and Mélon, gives the correct sequence of forms (the numbers in bold face in the above table are those which Donnay and Mélon assigned to the observed forms listed in the order of decreasing importance). The fourteen forms with the highest reticular densities are listed above the dashed line in the table, whether they be actually ob-

TABLE OF RETICULAR DENSITIES

No.	Form-symbols (Fedorov orientation)	D^2 (D =reticular density)
1	110	$4 \cot^2 45^\circ = 4.00$
2	1 $\bar{1}$ 0	$4 \cot^2 46\frac{1}{2}^\circ = 3.60$
3	011	$4 \cos^2 30^\circ = 3.00$
4	101	$4 \cos^2 30\frac{1}{2}^\circ = 2.97$
5	10 $\bar{1}$	$4 \cos^2 40^\circ = 2.35$
6	100	$\cot^2 34^\circ = 2.20$
7	0 $\bar{1}$ 1	$4 \cos^2 44\frac{1}{2}^\circ = 2.04$
9	010	$\cot^2 38^\circ = 1.64$
8	211	$4 \cos^2 53^\circ = 1.45$
	121	$4 \cos^2 56^\circ = 1.25$
10	$\bar{1}$ 21	$4 \cos^2 58^\circ = 1.12$
11	2 $\bar{1}$ 1	$4 \cos^2 58^\circ = 1.12$
	211	$4 \cos^2 58\frac{1}{2}^\circ = 1.09$
	2 $\bar{1}$ 1	$4 \cos^2 60\frac{1}{2}^\circ = 0.97$
<hr/>		
12	1 $\bar{2}$ 1	$4 \cos^2 62^\circ = 0.88$
13	111	$\cos^2 32^\circ = 0.72$
14	130	$4 \cot^2 68^\circ = 0.65$

served forms or "possible forms." These fourteen forms determine the numerator of the expression W (see below), which Fedorov considers a measure of the "correctness" of the adopted orientation. Three "possible forms," $\{001\}$, $\{1\bar{2}1\}$, $\{112\}$, occur below the dashed line and above form No. 12. The square of the reticular density is about 0.94 for all these three forms.

Fedorov's expression W , alluded to in the last paragraph, is: $W = R/J \cos 2a \cdot \cos v \cdot \cos t$, in which a , v , and t have the values 1° , 7° , and 14° , respectively, R is the sum of the squares of the reticular densities of the fourteen known forms, and J is the sum of the squares of the reticular densities of the fourteen theoretical forms with the highest reticular densities.

Substituting, we find: $W = 0.93$.

According to Fedorov's conception, this value of W makes the orientation very satisfactory.

It remains to be seen in what relation the two orientations stand with respect to each other. The three primitive translations of Fedorov's cell, reduced to the same scale as that of Donnay and Mélon, are:

$$\bar{a} = 1.381, \quad \bar{b} = 1.232, \quad \bar{c} = 0.935.$$

The unit-length c^1 is thus the same for both cells. Furthermore, a simple calculation shows that the parameter of the zone [110] in Donnay and Mélon's notation, is 1.383; while the parameter of their zone [111] is 1.231. The two lattices are then seen to coincide. The only difference lies in the choice of the unit-cell defining the lattice: whereas Donnay and Mélon emphasize the minimum lengths of the primitive translations, Fedorov aims at bringing out the pseudo-symmetry.

It gives us pleasure to acknowledge the constructive criticism received from Dr. J. D. H. Donnay, to whom we are further indebted for the translation of this manuscript.

NOTES AND NEWS

THE PSEUDO SYMMETRY OF ENARGITE

C. D. WEST, *Chemical Laboratory of Harvard University.*

While the external symmetry of the mineral enargite, Cu_3AsS_4 is pronouncedly orthorhombic, nevertheless an x -ray powder photograph (in Mo K radiation) of this material¹ can be completely indexed in terms of the following unit:

Hexagonal: $a=3.71$, $c=6.16$, $c/a=1.665$, $Z=2$ formulas of $\frac{1}{4}(\text{Cu}_3\text{AsS}_4)$, calculated density 4.42.

Characteristic extinctions: $hh.l$ with l odd.

The observed density is 4.3–4.5.

In dimensions this unit resembles that of hexagonal ZnS (wurtzite) which has $a=3.84$, $c=6.28$; moreover, the intensities of the some 25 lines are in general similar to those observed and calculated for ZnS.² Pseudo-hexagonal axes are obtained by doubling the crystallographic a and c axes as follows:

	$a:b:c$
Enargite orthorhombic	0.8713:1:0.8277 ³
Enargite pseudo-hexagonal	1.743 :1:1.655
Wurtzite hexagonal	1.732 :1:1.635
Hexagonal close packing	1.732 :1:1.632

The powder data thus permit the conclusion that enargite has a pseudo-hexagonal close packed structure similar to that of wurtzite.

In accordance with this conclusion a basal Laue photograph shows a number of strong interferences in a pattern indistinguishable from the symmetry of D_{6h} upon which is superposed a pattern of weak interferences with the symmetry of V_h only. Enargite thus illustrates the fallibility, as well as an advantage, of the powder method of crystal structure examination.

¹ From Butte, Montana.

² Fuller, M. L., *Phil. Mag.*, vol. 8, p. 658, 1929. Fuller gives for ZnS, $a=3.81$, $c=6.23$.

³ Recalculated by Professor C. Palache for the new edition of Dana's *System of Mineralogy*.

ENARGITE POWDER PHOTOGRAPH

$$1/d^2 = .0970(k^2 + hk + k^2) + .02625l^2$$

<i>hkl</i>	<i>obs.</i>	<i>calc.</i>	<i>Observed Intensity</i>	
			Enargite	ZnS (Fuller)
10.0	.0958	.0970	8	2
00.2	.1046	.1050	8	.8
10.1	.1231	.1232	9.5	1.9
10.2	.201	.202	5.5	.5
11.0	.289	.291	10	2.4
10.3	.334	.334	10	2.5
20.0		.388		vvw
11.2	.395	.396	6	.85
20.1	.4135	.4143	3.5	.15
00.4		.420	0	0
20.2	.492	.493	2.5	.1
10.4	.515	.517	.5	0
20.3	.625	.624	5	.55
21.0	.677	.679	2	.1
21.1	.705	.707	3	.1
11.4		.711		0
10.5	.752	.754	4.5	.4
21.2	.785	.784	2	
20.4		.808	0	0
30.0	.872	.872	3.5	.2
21.3	.917	.915	6	.65
00.6	.949	.947	.8	.1
30.2	.980	.977	3	
10.6}	1.045	{ 1.044	4	
20.5}		{ 1.045	1.5	
21.4		1.099	0	
22.0	1.163	1.162	1.5	
11.6	1.241	1.238	3	
31.0		1.260	0	
22.2		1.267	0	
31.1	1.283	1.286	1	
30.4		1.292		
20.6}	1.341	{ 1.335	5	
21.5}		{ 1.336		
31.2		1.365	0	
10.7	1.382	1.383	w	
31.3	1.496	1.496	3.5	
40.0		1.552	0	
22.4		1.582	0	

ORIENTATION OF CRYSTALLITES IN THE IGNITION
PRODUCTS OF $\text{Mg}(\text{OH})_2$ AND $\text{Ca}(\text{OH})_2$

C. D. WEST, *Chemical Laboratory of Harvard University.*

$\text{Mg}(\text{OH})_2$ (BRUCITE)

1. Bössem and Köberich¹ showed that when a single crystal plate of $\text{Mg}(\text{OH})_2$ (brucite) is ignited to MgO (periclase), the crystallites of MgO are in parallel grouping with a threefold axis $[111]$ parallel to the previous c -axis, and with a twofold axis $[\bar{1}\bar{1}0]$ parallel to the previous a -axis. This conclusion followed from the observation that on passing monochromatic x -rays normally through the ignited plate a pattern of discrete monochromatic spots with the symmetry of D_{3d} is obtained instead of uniformly blackened Debye circles. I have repeated this experiment and checked the description of these writers in detail. I also observed orientation of MgO crystallites with respect to the threefold axis on a rotation photograph of the ignited plate about the plate normal.

2. In a preceding note² I showed that on igniting a brucite fiber (Mg, Fe) $(\text{OH})_2$ the MgO crystallites here also have their $[\bar{1}\bar{1}0]$ axis parallel to the previous a -axis, that is, parallel to the fiber axis.

3. Some extra reflections on the x -ray photograph of this ignited fiber were attributed to the presence of a second oriented solid phase. Now since the ratio $\text{Mg}:\text{Fe}$ is about 4:1 by weight or 13:1 by atoms, it was suspected that this phase is the spinel MgFe_2O_4 (magnesio-ferrite). The accompanying table confirms the presence of the spinel and shows that it likewise has its $[\bar{1}\bar{1}0]$ axis in the fiber axis.

4. Since the unignited brucite fibers are highly elastic, the bent fibers were found to give focussed x -ray reflections.

$\text{Ca}(\text{OH})_2$

1. $\text{Ca}(\text{OH})_2$ ³ crystallized by a diffusion process⁴ shows hexagonal prisms with the forms 0001 (cleavage plane), $10\bar{1}0$ and oc-

¹ Bössem, W., Köberich, F., *Z. Physik. Chem.*, vol. 17, p. 310, 1932.

² West, C., *Am. Mineral.*, vol. 17, p. 313, 1932.

³ Natural crystals of $\text{Ca}(\text{OH})_2$ (portlandite) are described by Tilley, C., *Mineral. Mag.*, vol. 23, p. 419, 1933.

⁴ Prepared by Crove, C. See Johnston, J., Grove, C., *J. Am. Chem. Soc.*, vol. 53, p. 3976, 1931. The refractive indices of this material agree well with published values.

TABLE I. FIBER DIAGRAM OF IGNITED FE-BRUCITE
MgO and MgFe_2O_4 phases present with $[1\bar{1}0l]$ in the fiber axis

<i>d</i>	<i>hkl</i>	Powder Intensity		Observed Intensity in Layer Line					
		<i>S</i>	<i>P</i>	0	I	II	III	IV	V
2.96	220	5		vw/a	w				
2.53	311	10		m	m	m			
2.42	222	0	1	(M)		(M)			
2.10	400	5	6	(VST)		(VST)			
1.71	422	3		a	w	vw	w		
1.61	$\begin{Bmatrix} 511 \\ 333 \end{Bmatrix}$	$\begin{Bmatrix} 7 \\ \end{Bmatrix}$		$\begin{Bmatrix} m \\ \end{Bmatrix}$	$\begin{Bmatrix} w \\ \end{Bmatrix}$	$\begin{Bmatrix} w \\ \end{Bmatrix}$	$\begin{Bmatrix} m \\ \end{Bmatrix}$		
1.48	440	9	5	(VST)		(VST)			
1.42	531	0			0	0	0	0	
1.33	620	2			0	0	0	0	
1.28	533	2		0	w		vw	0	
1.26	622	0	4	(W)		(MW)		(M)	
1.21	444	0	5	(ST)				(ST)	
1.12	642	2			0	0	0	0	vw
1.09	$\begin{Bmatrix} 553 \\ 731 \end{Bmatrix}$	$\begin{Bmatrix} 4 \\ \end{Bmatrix}$		$\begin{Bmatrix} 0 \\ \end{Bmatrix}$	$\begin{Bmatrix} w \\ \end{Bmatrix}$	$\begin{Bmatrix} w \\ \end{Bmatrix}$	$\begin{Bmatrix} 0 \\ \end{Bmatrix}$	$\begin{Bmatrix} w \\ \end{Bmatrix}$	$\begin{Bmatrix} w \\ \end{Bmatrix}$
1.05	800	2	4	(M)				(M)	

Note: Column 1 gives the interplanar spacing.

Column 2 gives the indices of the spinel phase reflections.

Columns 3 and 4 give the observed intensities on powder photographs of spinel and periclase respectively; the former are taken from E. Posnjak, *Am. J. Sci.*, vol. 19, p. 67, 1930. The remaining columns indicate the observed intensities on the fiber photograph. The symbol (M) etc., indicates that this observed intensity is due primarily to the periclase phase.

casional narrow imperfect $10\bar{1}1$ faces, which however leave no doubt as to the trigonal symmetry. The axes are chosen to conform to the accepted structure axes ($c/a=1.41$) and were checked by *x*-ray methods. It is of interest first, that terminal faces other than the base have not previously been observed,⁵ and second that the isomorphous $\text{Mg}(\text{OH})_2$ (brucite, $c/a=1.51$) shows only $11\bar{2}0$ in the prism zone. The measured angle $0001:10\bar{1}1$ varies from $57-59^\circ$ with the average of several readings $58^\circ 18'$ or $c/a=1.41$.

2. As with $\text{Mg}(\text{OH})_2$ the ignition product of $\text{Ca}(\text{OH})_2$, or CaO , is a pseudomorph. On passing monochromatic *x*-rays through the base of the pseudomorph the Debye circles on the photograph are almost uniformly blackened; the conclusion is that there is little

⁵ Ashton, F., Wilson, R., *Am. J. Sci.*, vol. 13, p. 209, 1927.

orientation of the CaO crystallites in any direction normal to the previous c -axis. On the contrary a rotation photograph of the pseudomorph about the previous c -axis is exactly that expected for a [111] rotation photograph of CaO. Thus while the MgO crystallites were shown to be oriented in two directions the CaO crystallites are oriented only along one threefold axis.

EXPLANATION

The orientation of RO (or RFe_2O_4) crystallites with respect to the axes of the $\text{R}(\text{OH})_2$ from which it was formed will doubtless find its explanation in the similarity in structure of the three crystals. In all three structures six anions form an octahedron about each R atom; in all three structures the anions are in close packing, which is hexagonal in the hydroxide and cubic in the oxides. The simple relation between these two modes of packing is well known. The oxygen-oxygen distances (octahedron edges) and the anion-cation distances are as follows if the variable parameter of $\text{R}(\text{OH})_2$ is $u = .25$.

	Mg(OH) ₂	MgO	MgFe ₂ O ₄	Ca(OH) ₂	CaO
0-0	3.13, 2.98	2.98	2.96	3.58.3.26	3.39
R-6 0	2.16	2.10	2.09	2.42	2.40

From a structural point of view the pair $\text{R}(\text{OH})_2$ -RO is the analog of the pair MgBr_2 -LiBr. The similarity in structures of LiBr and MgBr_2 expresses itself in the miscibility of these substances in the solid state.⁶

A new edition of United States Geological Survey Bulletin 679, "The microscopic determination of the nonopaque minerals," has just been published as Bulletin 848 and may be obtained from the Superintendent of Documents, Washington, D. C., for 20 cents. The new edition of 254 pages has been completely rewritten and the tables brought up to date by the introduction of about 500 new entries and 100 changes in old entries. About 250 new mineral species not given in the old edition are included, and tables have

⁶ Ferrari, A., Colla, C., *Atti. Accad. Lincei*, vol. 13, p. 78, 1931. International Critical Tables, IV, p. 63.

been added in which the data on the important mineral groups have been assembled. The new edition will therefore entirely supersede the earlier one and will be a necessary reference work for all those who have occasion to identify minerals.

PROCEEDINGS OF SOCIETIES

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

MINERALOGICAL SOCIETY, *March 15*, MR. ARTHUR RUSSELL, Vice-President, in the chair.

MR. ARTHUR RUSSELL: *Baryte crystals from the Manvers Main Colliery, Walk upon Dearne, near Rotherham, Yorkshire.* A cavity containing exceedingly beautiful colourless crystals of baryte was discovered in the roof of the Parkgate Seam of this colliery in 1930, and the occurrence was briefly described by Mr. C. P. Finn in the same year. Two distinct habits of crystals occurred, prismatic and tabular. The crystals are attached to small coloured rhombohedra of dolomite which form a coating on the grey sandstone, both baryte and dolomite being for the most part more or less thickly sprinkled with small bright twinned crystals of chalcopyrite. The crystal forms present are listed and drawings of the crystals are given.

DR. W. Q. KENNEDY: *The conditions for the crystallization of hornblende in igneous rocks.* By means of a statistical study of the MgO-CaO-FeO ratios of igneous hornblendes it is shown that the latter occupy an intermediate position between the diopsidic pyroxenes and the magnesia-rich, lime-poor monoclinic and orthorhombic pyroxenes. It is concluded, therefore, that (1) pressure and the concentration of the volatile constituents are not the sole determining factors in the crystallization of pyroxene and hornblende from a magma but that the original proportions of the constituent oxides play an equally important part; (2) a magma which, under physical conditions tending towards the retention of the volatile constituents, will produce hornblende as its ferromagnesian constituent will, under effusive conditions, produce diopsidic pyroxene plus hypersthene or enstatite-augite. Thus hornblende = diopsidic pyroxene + orthorhombic pyroxene or enstatite-augite (pigeonite).

MR. ARTHUR RUSSELL: *An account of British mineral collectors and dealers in the 17th, 18th, and 19th centuries (continued).* John Williams of Scorrier House, Cornwall, mine agent and adventurer, copper and tin smelter and banker, born September 23, 1753, died April 17, 1841. The collection of Cornish minerals which he had formed at Scorrier in conjunction with his son John, born August 3, 1777, died August 11, 1849, was greatly added to by the latter. The collection which contained about 10,000 specimens was one of the three finest in Cornwall. In 1893 Mr. John Charles Williams disposed of the collection by presentation between the British Museum, The Royal Institution of Cornwall, Truro Museum and the Robert Hunt Memorial Museum, Redruth. In addition to a memoir of both the Williams, a general account of the collection and its outstanding specimens is given.

M. H. HEY: *On the advantages of the face-adjustment for two-circle goniometry.* The statement often made that an accurate projection cannot be so quickly prepared from two-circle measurements made with the face-adjustment as from measurements made with the zone-adjustment is shown to be incorrect, and a construction for the preparation of a projection is described. The face adjustment has several decided advantages over the zone-adjustment.

The following papers were taken as read:

M. H. HEY: *An improved method of crystallographic computations.* A system for the computation of the elements of a crystal from two-circle goniometric measurements is described in which due weight is given to each measured angle in accordance with its estimated probable accuracy.

M. H. HEY: *On face- and zone-symbols referred to hexagonal axes: a correction.* The system of four-index hexagonal zone-symbols described by L. Weber is correct, and that formerly described by the author is abandoned. The derivation of Weber's symbols from a gnomonic or linear projection is described, and their relation to the "three-index" symbols noted.

PHILADELPHIA MINERALOGICAL SOCIETY

The Academy of Natural Sciences of Philadelphia, March 1st, 1934

President Gillson called to order a stated meeting of the Society, 38 members and 27 visitors being present.

Prof. Paul F. Kerr of Columbia University addressed the Society on the "Mill City, Nevada, Tungsten Deposits." Prospecting for commercial tungsten deposits was greatly encouraged during the War and some 25 prospects were located in the 300 odd Mountain ranges of Nevada. The principal ores are scheelite and huebnerite. Mill City in the Eugene Range is the largest producing center in the United States at present, the annual production being 1000 tons of concentrates. These 300 odd Mountain ranges represent different mineralized fault blocks, and the Eugene Range yields mercury, molybdenum, silver, tungsten and gold. Mill City, Silver Dike and Paradise Range represent three different types of tungsten deposits, and the Betty O'Neal Mine in the Paradise Range is estimated to contain 5,000,000 tons of brucite, in which are located pockets of scheelite. Three important mines are located at Mill City, the Humboldt, Springer and Stank, which represent a concentration of tungsten in a vein-like deposit 6 to 8 feet wide and 800 feet deep. The rocks are Triassic in age and younger. Quartz, garnet, calcite and epidote are associated with the scheelite. The deposit is a typical contact metamorphic deposit. Owing to the great similarity of the appearance of the scheelite and the associated quartz, iron arcs have recently been installed above and below ground for determining the scheelite by fluorescence.

In the discussion which followed it was shown that it would not be practical to explore the granodiorite which underlies the ore deposit irregularly, by geophysical methods, but would be much simpler to drill. Prof. Kerr's talk was splendidly illustrated with lantern slides. The Society gave him a rising vote of thanks.

W. H. FLACK, *Secretary*

The Academy of Natural Sciences of Philadelphia, Pa., April 5, 1934

President Gillson presided at a stated meeting of the Philadelphia Mineralogical Society with 39 members and 32 visitors present. Mr. Wm. Van Horn was elected to senior membership.

President Gillson opened the discussion of the evening, a "Symposium on the Tri-State Lead-Zinc District" with an account of the geology and economic importance of the region, which covers parts of Missouri, Kansas and Oklahoma.

Mr. Arndt, in the absence of Mr. Chas. R. Toothaker, read of Mr. Toothaker's personal collecting experiences in the district. He described one cavity in the mines which contained a scalenohedron of calcite $2\frac{1}{2}$ feet across and over 5 feet long. Fully 18 inches of the tip was broken off, and floor, walls and ceiling of the cavity were covered with calcite, marcasite, dolomite and galena.

Mr. J. R. Frorer described one of his frequent trips into this region, exhibiting a number of very fine specimens of crystallized galena, sphalerite, marcasite, barite, calcite twins, calcite enclosing bitumen, and ruby blende.

Mr. Cienkowski exhibited six large specimens of crystallized galena, coxcomb marcasite and calcite, and a golden calcite on pink dolomite, and described their collection.

W. H. FLACK, *Secretary*

LEHIGH VALLEY ROCK AND MINERALS CLUB

There has recently been organized in the Lehigh Valley a Rocks and Minerals Club. The plan is to arrange for occasional trips during the spring, summer and fall to places of mineralogical and geological interest, and especially to localities favorable for collecting. During the winter months, there will be occasional evening programs.

Dr. Donald M. Fraser of Lehigh University is chairman of the Club. The other members of the executive committee are Mr. Floyd R. Faux, of Bethlehem, secretary; Professor Charles Cabeen, of Lafayette College, Easton, Pa.; Professor Albert Fasig, of Muhlenberg College, Allentown, Pa.; and Mr. John McNeal, of Easton, Pa.

NEW HAVEN MINERAL CLUB

The fourth meeting of the New Haven Mineral Club proved a most successful one, with almost all of the members in attendance. Mr. Edward Leith of Yale University gave an interesting, illustrated talk on "Fossil Collecting" showing slides of some of the specimens. He also spoke of the Yale expedition to Nova Scotia which gave the club members a good idea of the geology of that country.

The club also had an unexpected guest in Mr. John Grenzig of Brooklyn who is a very enthusiastic mineral collector. Mr. Grenzig gave an impromptu talk on the "Zeolites of Paterson, New Jersey."

The club has about 45 members at the present time and is seeking new recruits. Some of the members have taken up the cutting and polishing of specimens and semi-precious stones and it is hoped that this activity will become very popular.

LILLIAN M. OTERSEN, *Vice-President*

NEW MINERAL NAMES

H. UNGEMACH: Sur quelques minéraux nouveaux, *Compt. Rend.*, vol. 197, pp. 1132-1134, 1933.

Paracoquimbite

A form of coquimbite with two cleavages along (10 $\bar{1}$ 1) and (01 $\bar{1}$ 2), and $c=2.3464$. Frequently twinned on the base and intergrown with coquimbite. Color, pale violet. Composition, same as coquimbite. Locality, Sierra Amarilla, Chile.

Amarillite

A sulfate of ferric iron and soda: $\text{Na}_2\text{O} \cdot \text{Fe}_2\text{O}_3 \cdot 4\text{SO}_3 \cdot 12\text{H}_2\text{O}$. Monoclinic. $a:b:c=0.7757:1:1.1482$. $\beta=84^\circ 23'$. Color, pale yellow. Cleavage, $m(110)$ good. Analogous to tamarugite.

Lapparentite

A sulfate of alumina: $\text{Al}_2\text{O}_3 \cdot 2\text{SO}_3 \cdot 10\text{H}_2\text{O}$. Monoclinic. $a:b:c=0.2919:1:0.24155$. $\beta=85^\circ 10'$. Glassy. Cleavage, (010) good. Very soluble in water.

Leucoglaucite

A sulfate of iron. $\text{Fe}_2\text{O}_3 \cdot 4\text{SO}_3 \cdot 5\text{H}_2\text{O}$. $c=0.5589$. Color, pale greenish blue. Cleavage, (11 $\bar{2}$ 0) good.

W. F. FOSHAG

Mineralogischen Taschenbuch der Wiener Mineralogischen Gesellschaft, 1928.

R. KOEHLIN. *Centr. Mineral.*, 1933A, pp. 202-04.

Names on mineral labels but with no published descriptions.

Melosark = melopsit

Gränzerite and pseudo-orthoclase = sanidine

Knollite = zeophyllite

W. F. F.

NEW DATA

Matlockite

W. NIEUWENKAMP: Die Chemische Zusammensetzung von Matlockite, *Zeit. Kryst.*, vol. 86, pp. 470-471, 1933.

By a comparison with x -ray diagram of PbFCl and a chemical determination of fluorine (6 $\frac{1}{2}$ %), it is shown that matlockite has the chemical formula PbFCl , instead of Pb_2OCl_2 .

W. F. F.

Swedenborgite

G. AMINOFF: On the structural and chemical composition of Swedenborgite, *Kungl. Svenska Vetenskapsak. Handl.*, Ser. 3, vol. 11, pp. 3-13, 1933.

CHEMICAL PROPERTIES: An antimonate of beryllia and soda, $8\text{BeO} \cdot \text{Na}_2\text{O} \cdot \text{Sb}_2\text{O}_6$. Analysis (by R. Blix): Sb_2O_5 55.41, P_2O_5 0.63, BeO 34.92, CaO 0.90, MgO 0.65, Na_2O (by diff.) 8.49.

CRYSTALLOGRAPHIC PROPERTIES: $c=8.80\text{\AA}$, $a=5.42\text{\AA}$. $c:a=1.624$.

W. F. F.

DISCREDITED SPECIES

Partschinite

Otto Zedlitz: Über Partschin, *Centr. Mineral.*, 1933A, pp. 297-299.

Comparison of the x-ray diffraction pattern of partschinite from the type lot and of spessartite shows them to be identical; cf. Esper S. Larsen, *Am. Mineral.*, vol. 2, p. 20, 1917.

W. F. F.

CORRECTION

On page 220 of the May issue of THE AMERICAN MINERALOGIST beginning with the fourth line of the footnote the sentence should read: "Molybdenum is present in germanite and sphalerite to the amount of 0.01%–0.001% molybdenum."